Endorsement of gender stereotypes affects high school students' science identity

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We investigated how the endorsement of gender stereotypes affects disciplinary identity across three different science-technology-engineering-mathematics (STEM) areas: physics, biology, and chemistry, and whether such relationship is mediated by self-concept constructs, such as self-efficacy and perceived academic control. Building on the ambivalent sexism theory and masculine ideology paradigm, we focused on gender stereotypes based on hostile and benevolent sexism and on male role norms. A sample of 1406 Italian high school students (girls = 742) was involved in the study. Structural equation modeling was used to test the hypothesized relationships. Results show that the adherence to male role norms and the rejection of hostile sexism have a significant effect on the development of a disciplinary identity in the three targeted STEM domains. However, such an effect is fully mediated by self-efficacy and perceived academic control. Moreover, the identity in the three addressed STEM domains is differently affected by the endorsement of stereotypes, with physics and biology being more largely affected than chemistry. More importantly, the endorsement of hostile sexism stereotypes significantly decreases the perceived self-efficacy, while higher levels of perceived academic control are predicted by higher levels of endorsement of male role norms, for both girls and boys. Our findings suggest that to reduce the perception of femininity as incongruent with STEM identification, it would be necessary to deconstruct the masculine view of self-efficacy and academic control.

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I. INTRODUCTION

The role that society attributes to people on the basis of their gender characteristics affects their personal life, educational choices, and work experience [1–3]. This mechanism often limits personal and professional fulfillment, especially for women, and it can be due to a multiplicity of social, cultural, economic, educational, and institutional factors [4–8]. The consequences are significant, not only at the individual but also at the social and economic level, as they result in a lack of exploitation of competent and qualified human resources, with detrimental effects on the society [9–11]. Although it has been widely demonstrated that men and women possess quite similar skills, methods, and general approach to problem solving [12,13], some areas of study and work, such as those related to science-technology-engineering-mathematics (STEM), are absolutely male dominated, with women being confined in areas with lower employment, career, and income prospects [14]. The most recent European Commission's She Figures report shows that since 2010, overall gender parity among doctoral graduates has been almost reached, yet gender differences tend to be persistent across fields of study [15,16]. A similar gap exists also at the job market level. In particular, as reported in the 2022 report on gender equality in the European Union (EU) [17], women account for most of the employees in sectors such as education, health, and social care (over 70%), as well as public services and retail (over 60%) [18].

Italy ranked 63rd of 146 countries on Global Gender Gap Index published by World Economic Forum, which means that gender gap in the four targeted fields (economic participation and opportunity, educational attainment, health and survival, political empowerment) is yet to be closed [19]. Such disparity traces back to gendered educational patterns. In Italy, as in most industrialized countries, the majority of the university student are women, but few graduate in STEM disciplines [20–22]. Such gender segregation can contribute to women's underrepresentation in higher-paid sectors and overrepresentation in lower-paid

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sectors [23,24]. Therefore, studying which factors affect the choice of a career in STEM disciplines with different levels of gender segregation, such as physics, biology, or chemistry [24], is of the utmost importance since the results can be useful to undertake actions that impact on the above-described gender gaps.

This paper intends to contribute to the research on female underrepresentation in the STEM field by investigating how the endorsement of gender stereotypes affects disciplinary identity, which has been consistently shown to be related to career choices in STEM [25–27]. Moreover, we aim at examining how such relation is mediated by self-concept constructs, such as self-efficacy and perceived academic control, which predict achievement and performance in STEM-related fields [28,29] and are believed to explain women's underrepresentation in physics in comparison to biology and chemistry [30].

II. BACKGROUND

A. Psychological models to explain gender stereotypes in STEM

Gender stereotypes consist of mechanisms of categorization, interpretation, processing, and decoding of the sexual reality [31–33]. Thus, they are socially shared representations of the differences between the masculine and the feminine, already active in the processes of primary and secondary socialization [34,35]. Overall, gender stereotypes form a system of beliefs and conceptions inherent in male and female identities in relation to the characteristics of personality, behavioral traits, attitudes, and abilities that are considered socially and culturally adequate for men and women [36–39]. STEM-related gender stereotypes primarily consist of the perception of the existence in the STEM student population of specific, male-related, characteristics, which systematically exclude girls and women [20]. For instance, some authors found that the gender of applicants for a STEM research position conditioned the commission's assessment in favor of men [40]. Similarly, other studies showed that, compared to a woman, a man was twice as likely to be hired for a position that required mathematical skills [41]. However, gender stereotypes in STEM may also consist of a socially shared representation of gendered characteristics, confused with biological sex, of the STEM disciplines [42]. For instance, young female students may not be interested in STEM careers because of their perception of these subjects as predominantly masculine [43–47] and even when they choose STEM disciplines, girls can be implicitly guided toward courses and careers where the percentage of girls is perceived as higher [48]. Literature has also shown that the endorsement of stereotyped views of STEM disciplines may affect career choice [26].

Glick and Fiske [49–52] proposed a model based on the notion of ambivalence to explain the endorsement of gender stereotypes in cultural and social contexts dominated by a specific group or perceived as such. Essentially, in this model, cultural and social relationships, such as the one between women and men, are multifaced and characterized by feelings based on ambivalent attitudes. The extensive work by Eagly and colleagues shows that the ambivalence may arise in contexts where men have social, political, and economic power or where the men or women's job division corresponds to the work and care dichotomy [53–57]. In the Glick and Fiske model, the ambivalence is conceptualized in terms of two dimensions, hostile sexism and benevolent sexism. The first component is based on the belief that it is legit that men hold more power than women and on the fear that women can seize such power. Examples are that men are the only ones that can take decisions in a family or that women should not complain about job discrimination. Such hostile attitudes are counterbalanced by benevolent and protective attitudes. Examples are that the man should protect his woman or that women are the purest human beings. Drawing from both dimensions, gender stereotypes arise to legitimate and preserve power relationships, justifying social and economic differences. In particular, gender stereotypes aim to legitimate men's superiority in certain competences that are deemed relevant for a given context, whereas acknowledging women's superiority in competences that are relevant in nonprofitable contexts such as care or teaching. Literature about ambivalent sexism has shown that benevolence and hostility toward women are able to predict, respectively, positive and negative attitudes toward women in different cultural contexts, as well as the degree of gender inequality across nations [58,59] or relationship ideals [60].

A second model that can be used to explain the endorsement of gender stereotypes is the gender role strain paradigm [61,62]. According to this model, roles attributed to women and men are conceptualized as the result of social processes guided by gendered ideologies. For our study, it is relevant to the masculinity ideology that is defined as a set of internalized beliefs about culturally defined standard roles and behaviors for men [63]. Masculinity ideology leads boys and men to conform to a given role by adopting socially accepted masculine behaviors, and, at the same time, by avoiding certain prohibited feminine behaviors [37,38,64,65]. However, cultural conventions and social interactions that reinforce and encourage the endorsement of the masculinity ideology are learned by both men and boys and women and girls and this leads to gendered views regarding the appropriate behavior that men and boys should have in a certain cultural context [66]. The model features five dimensions [67]: avoidance of femininity, self-reliance, aggressivity, achievement and status, and restrictive emotionality. The endorsement of a masculine ideology along these dimensions predicts negative attitudes toward women's equality [68] and problematic behaviors toward women [66]. Moreover, masculine ideology predicts the nonparticipation of undergraduate students with low performances in tutoring and mentoring programs [69].

Both the ambivalence and the role norm models may explain gender stereotypes in STEM. As already pointed out for sexism, gender differences in STEM can assume a hostile form or a benevolent form. Hostile forms refer to the beliefs that boys perform better in "hard sciences," e.g., physics and math since they are more able and competent in solving tasks that require abstract thinking and spatial reasoning [70]. Benevolent feelings refer to the belief that girls choose STEM careers related to life and health sciences since they are more competent in the care and affective fields [71–73]. Similarly, social norms adopted in certain STEM fields, such as physics [74,75] may resemble a masculine image of the field, thus leading to the creation of a role norm to which both boys and girls must conform to be accepted in that field. Given that adolescence is a time of enhanced conformity in many life aspects, including those related to gender, a perceived unfriendly and unwelcoming culture, with a negligible visibility of women in professional and academic careers, may decrease girls' identification and self-beliefs in the field [44,76–78]. In the model described in Ref. [30], the masculine culture is a possible factor explaining women's underrepresentation in certain STEM fields (such as physics) with respect to others (such as chemistry or biology). Drawing on a review of about 300 papers, the authors identify three components in their model: (i) stereotypes associated with the people working in the field; (ii) stereotypes about women's ability in STEM, and (iii) lack of female role models. These three components negatively affect the way girls and women see themselves in relation to specific STEM fields, such as, for instance, physics. This model was adopted to explain women's underrepresentation in STEM fields in two culturally different countries such as Japan and the United Kingdom [79]. In particular, a fourth dimension was added to the model called social climate surrounding gender roles. This factor accounts for gender equality, the view about university education, the attitude toward intellectual women, and attractiveness to the opposite sex. With this expanded model, the authors show that, in Japan, negative attitudes toward intellectual women significantly predicted a view of mathematics as a masculine field, whereas in the United Kingdom, the attractiveness to the opposite sex was significantly related to the view of physics and mathematics as masculine fields. Such results suggest that also social climate contributes to seeing STEM, or at least some areas of STEM, as masculine.

B. Disciplinary identity

The three components of the masculine culture of the STEM field in the model described in [30] all contribute to decrease women's sense of belonging in the STEM field. Sense of belonging is a component of the widely used model of physics identity [80,81], recently extended to include the more general STEM field [82]. Therefore, for this study, we included the construct of disciplinary identity as a key factor to explain gender disparities in STEM. This choice is also along the lines of recent studies that show that one way to deconstruct gender stereotypes in STEM is to foster the development of a disciplinary identity related to the specific field of interest [83,84]. In the present study, we define identity as the understanding of the self and of the others in relation to a context, a discipline, and a professional workplace [85–90]. More specifically, STEM identity frames the perceptions about STEM in terms of self-process and social relationships [91]. According to this theoretical perspective, the identity that an individual develops, for instance, in relation to a STEM field like physics, is the result of his or her perceptions of that field and of the shared beliefs, expectations, values, language, and rules of that field.

In the conceptualization proposed in [80,81], STEM identity is predicted by four constructs: performance or competence, interest, recognition, and sense of belonging. In this conceptualization, the performance or competence represents the student's metacognitive belief about what one is capable of doing or learning in a specific subject. Interest refers to the students' preference to engage in some types of activities rather than others. Recognition is conceptualized as a student's own perception of how others (for instance, peers, teachers, parents, and experts) view them in relation to the discipline. Sense of belonging can be defined as a student's perception of being emotionally related, accepted, and included by teachers and peers in a community of learning.

Studies in general higher education show that persistence and academic performance at the university level are related to a strong identification with the discipline [92], rather than ethnicity or the social group of belonging [93,94]. This finding has been thoroughly confirmed by studies in physics and engineering education [95–97]. Other studies show that male students have a higher STEM identity than their female colleagues [98]. On such basis, the study of disciplinary identity can be a way to identify possible causes for why girls do not choose STEM careers and to prevent female dropout in STEM disciplines.

Research findings have also thoroughly shown that implicit stereotyped views in science and engineering, such as the beliefs about the different abilities of women and men, may affect disciplinary identity. In particular, for women enrolled in STEM courses, gendered stereotypes of science were associated with weaker science identity, whereas for men, stronger gender-science stereotypes were associated with stronger science identification [99–103]. Similarly, a recent study in Italy confirmed that implicit STEM-gendered stereotypes were negatively associated with female students' STEM major intentions [104]. Finally, a stereotypical STEM classroom environment can reduce girls' sense of social belonging [105,106], and this in turn may negatively affect disciplinary identity in STEM.

C. Self-efficacy

Another relevant factor in the model described in Ref. [30] is the gender gap in self-efficacy. Self-efficacy can be defined as an individual's belief about their capabilities to produce designated levels of performance or to exert influence over events that affect their lives [107]. Self-efficacy beliefs strongly influence people's feelings, thoughts, motivations, and behavior [108]. An individual with a strong self-efficacy usually has high confidence in his or her own capabilities to successfully overcome difficulties and tends to approach difficult tasks as challenges to be mastered. Previous studies have shown that self-efficacy affects the performance in a given context or discipline [109,110] and the identity of the person in that context or discipline [78]. Furthermore, the different extent to which one perceives his or her own abilities predicts the persistence in career-related choices [111].

The relationship between self-efficacy and gender has been thoroughly explored. Studies report girls' lower self-efficacy in STEM-related careers [112] and in STEM-relevant competencies [113–115]. Self-efficacy also directly affects girls' attitudes toward STEM disciplines [116,117] and mediates the effects of gender on interest and achievement in STEM [118–120]. While such evidence may explain why women are less attracted to STEM careers than men, the reason for why women tend to show lower self-efficacy than boys in STEM disciplines has been hardly investigated. One possible reason may be related to gender stereotypes according to which men and women are differently associated with competence in various fields [52]. In particular, since among the sources of self-efficacy, there are performance achievements and vicarious learning, fewer learning experiences in domains that are dominated by one gender may result in lower self-efficacy for the other gender [121]. Concerning STEM disciplines, self-efficacy presumably plays a relevant role in the relationship between gender and disciplinary identity [28,71,122,123]. As a consequence, even when learning experiences are similar, stereotypical association of competence with men may lead women to be underconfident in their performance [73,113]. However, the difference between men's and women's self-efficacy may differ across STEM fields. In particular, such difference is the greatest in computer science and engineering [124], smallest in biology, and not detected in chemistry [125], thus suggesting that disparities in self-efficacy follow the same patterns of gender participation in a given field.

D. Academic control

Research has shown that persistence in STEM academic career is predicted by both self-concept and prior performance variables [126] and that these variables significantly interact with gender [127]. According to the theory of planned behavior [128], both self-concept variables and performance variables may be predicted by three overarching constructs: attitudes, subjective norms, and perceived behavioral control. The latter construct describes the individual's perception of control of external factors related to the specific behavior to be enacted [128]. External factors may differ across situations: for instance, in the school context, an external factor may be the probability that a teacher gives a difficult task in a summative assessment. For the purpose of this study, we will focus on perceived academic control, which is conceptualized as the individual's belief to be able to influence their own success in a given environment by controlling such external factors [129–131]. This individual's belief may be affected by past experience, second-hand information, peer experiences, and personal judgments [128]. Much empirical work focused on the relationship between perceived academic control and outcome variables such as persistence, performance, and expectations in relation to career and interest in a given field [132,133]. Other studies found that higher levels of perceived control are correlated to lower levels of stress and depression [134], and to higher levels of motivation and use of self-monitoring strategies [130,132].

Perceived academic control is also somewhat related to self-efficacy [135], in that the theory of planned behavior includes self-efficacy in a wider framework [128]. However, different from self-efficacy, the relationship between perceived academic control and gender has not been fully explored. For instance, some authors found no empirical support for a gender difference in perceived academic control [29]. However, this may simply be due to inadequate research design. In male-dominated contexts, gender stereotypes related to ambivalent sexism and male role norms may increase girls' stress and, at the same time, lower their motivation and self-efficacy [136,137], thus decreasing also the perceived academic control. Moreover, in masculine contexts where they are underrepresented or negatively stereotyped, girls could feel themselves less "in control" and underconfident in specific tasks, resulting in an academic performance that is below their expectations [132]. Hence, especially for girls, perceived academic control may be negatively affected by the endorsement of gender stereotypes.

III. RESEARCH QUESTIONS

From the above-reviewed literature, it is possible to infer that gender stereotypes play a relevant role in the girls' lack of identification with physics and other STEM disciplines. However, most of the previous studies in physics and science education used the decontextualized implicit association test to assess gender-science stereotypes (e.g., "boys perform better in math"). No study has yet investigated whether the explicit endorsement of gender stereotypes, such as those related to ambivalent sexism and male role

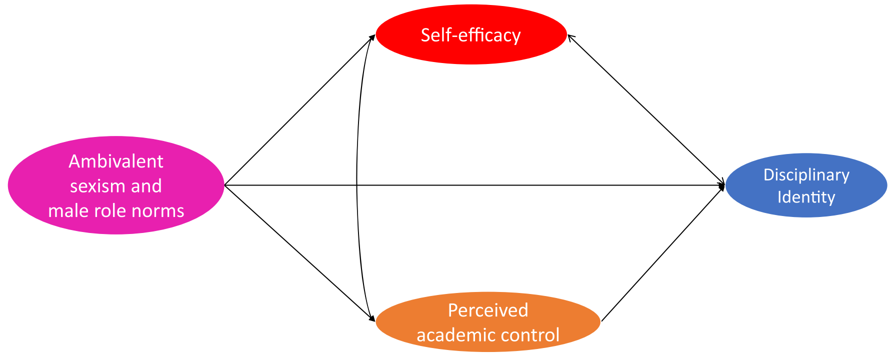

FIG. 1. Hypothesized model of relationships between gender stereotypes (ambivalent sexism and male role norms), self-efficacy, perceived academic control, and disciplinary identity.

norms, may affect the disciplinary identities of girls and boys in STEM fields, and whether the strength of such relationships depends on gender. From a psychological point of view, the link between disciplinary identity and endorsement of explicit gender stereotypes related to sexism and role norms can be explained by considering that the development of the disciplinary identity is a socially constructed process, given the influence of constructs as a sense of belonging and recognition by others. Hence, as any socially constructed process, the development of disciplinary identity begins at a young age and is affected by the development of gender roles and gender-typed behaviors for children and adolescents that continue into adulthood [138]. Furthermore, endorsement of masculine norms may lead men to shape an identity that is more strongly influenced by competition, rigor, toughness, and possible greater earnings. These are all perceived features of the STEM disciplines [139] at odds with stereotyped feminine personality traits [140]. Finally, we note that prior studies mainly involved samples of graduate and undergraduate STEM students, often with no distinction between the different disciplines. Disaggregating STEM fields can provide a more powerful lens through which to evaluate underrepresentation in specific STEM fields [30]. In particular, no study has yet involved secondary school students with a different orientation toward STEM areas with distinct patterns in gender representation as physics (male dominated), chemistry (balanced), and biology (female dominated) [24]. Hence, the first research question that guided the study is

RQ1: Does the endorsement of gender stereotypes affect disciplinary identity in physics, chemistry, and biology? If so, for which gender and for which domain the endorsement of gender stereotypes has the strongest effect?

The reviewed studies are also limited in that they do not delve into the net of relationships between gender stereotypes, disciplinary identity, self-efficacy, and perceived academic control. In particular, despite the relevance of both self-efficacy and perceived academic control for choosing, persisting, and succeeding in a STEM career, there is a lack of studies investigating the extent to which the endorsement of gender stereotypes may affect differences in self-efficacy and perceived academic control in male-dominated STEM areas, such as physics, and if there are differences with female-dominated STEM areas, such as biology. Given the results discussed in the background section, we will consider self-efficacy and perceived academic control as mediating variables. Thus, the second research question that guided our study was

RQ2: Do self-efficacy and perceived academic control mediate the relationships between gender stereotypes and disciplinary identity in physics, chemistry, and biology? If so, for which gender and for which domain the mediation has the strongest effect?

The relationships envisaged in the research questions are summarized in Fig. 1.

IV. METHODS

A. Instructional context

This study was carried out in the context of Italian upper secondary school (grades 11th–13th, age 16–18). In Italy, upper secondary school is divided into two main streams: lyceums and technical or vocational schools. Lyceums can be broadly divided into humanities-focused lyceums ("classical," "sociopedagogical," "linguistic", "art") and math-science-focused lyceums ("scientific", "applied sciences"). Technical schools broadly cover technological and economic fields, while vocational schools broadly cover third-sector services, industry, and handicrafts. In lyceums, all students from 11th to 13th grade must attend on average 4 h of math, 2 h of physics, and 4 h of natural sciences, which include biology and chemistry, per week. In technical or vocational schools, all students already address basic contents of biology, chemistry, and physics in 9th and 10th grade so that in 11th and 13th grades can address more specific contents depending on the specific stream (e.g., electronics, telecommunication, computer science, biotechnologies, etc.). As far as gender distribution in the different streams, the most updated, albeit unofficial, statistics reported in Ref. [141] show that humanities-focused lyceums are female segregated (on average, 75%), math-science-focused lyceums are slightly male segregated (on average, 59%), while technical or vocational schools are male segregated (83%).

The specific biology, chemistry, and physics curriculum contents are loosely described in the so-called *National Indications* for each stream (see Ref. [142] for lyceums). From grade 11th to 13th biology syllabus for all kind of lyceums dictates on average that students will learn about complex biological systems and their interactions, the structure and functions of DNA, proteins, basic elements of genetics, anatomy, and physiology. Chemistry syllabus on average requires that students will learn the classification of the main inorganic compounds and the related chemical nomenclature, stoichiometry, atomic structure, and atomic models, the periodic system, periodic properties and chemical bonds, acid-base, and redox reactions. In 13th grade, chemistry and biology are intertwined in biochemistry, addressing the structure and function of molecules of biological interest, placing emphasis on biological and biochemical processes, genetic engineering, and its applications. The physics syllabus dictates that students will learn basic concepts in kinematics and mechanics, Newton's principles, energy conservation, basic elements of rigid bodies dynamics, thermodynamics, electrostatics and electrodynamics, mechanical and electromagnetic waves. In 13th grade, students of scientific lyceums will also learn basic elements of relativity and "modern" physics such as photoelectric effect and Bohr's atomic model. The main difference between scientific lyceums and other lyceums is the possibility to use basic elements of calculus (e.g., derivatives and integral) to address physics contents. However, this strongly depends on the teacher, as the National Indications do not mandate the way in which the syllabus contents should be addressed.

The majority of in-service, permanently appointed, teachers in Italian upper secondary schools are on average women (about 68% for lyceums and 60% for technical or vocational stream [143]). To the best of our knowledge, statistical data on the gender distribution of the teachers for the school subjects targeted in this study (biology, chemistry, and physics) are not officially available. Similarly, official data about teachers' educational background are also not available at the national level.

B. Sample and procedure

This study took place between December 2021 and January 2022. Students of our sample voluntarily chose to participate in extracurricular biology, chemistry, and physics activities organized by our university as part of the activities of the Piano Lauree Scientifiche (PLS) promoted by the Italian Ministry of University and Research (MUR). The activities took place in the afternoon, as postschool day sessions. The PLS activities have three main objectives: (i) enhancing high school students' awareness of the role of science in everyday life; (ii) engaging students in laboratory activities and short researchlike experiences at the university; (iii) describing possible job opportunities given by scientific degrees. In general, high school teachers have a positive attitude toward PLS activities since these are considered an opportunity for students to self-assess their knowledge of concepts addressed in the usual science curriculum and for teachers to familiarize with new pedagogical methods such as inquiry. When registering for the activities, students were informed that the activities would have been implemented both in presence and in remote-learning modality due to the then ongoing measures contrasting the COVID-19 pandemic. The rationale and syllabus of the PLS activities were formally described in a document sent by email to all upper secondary schools in the town district of our university and shared through social channels and the university website. To participate in the activities, upper secondary schools had to apply by replying to the received email and by indicating a couple of teachers in charge of disseminating the PLS information in the school. As the PLS activities also target underage students (16–18 years), contact teachers had to collect informed consent from the students' parents asking for permission to use students' answers for research purposes. The consent form was not mandatory to participate in the activities. To preserve anonymity, we sent the teachers in each school a series of ID numbers that they associated with their students without communicating the association name-ID to us. For the purpose of this study, students filled in the designed survey (see next section) before the beginning of the activities using the received ID so that all data for this study were collected anonymously. Teachers then reported to us only the association between IDs and gender and the list of students' IDs whose parents did not give consent for research purposes to exclude those data from the database. At the time when the study was carried out, ethical approval of our research from our departments was not required.

Overall, 60 upper secondary schools applied to the PLS activities. Eighteen were technical or vocational schools, 42 were Lyceums, 6 were humanities-focused ("classical" lyceum), and 36 were math-science focused (scientific and applied sciences lyceum). On average, each school participated with about 20–25 students for a total of 1406 students. For each school, a maximum of 3–4 students per class was allowed. Of the 1406 students, only 17 did not agree to participate in the study.

The final sample was constituted of $N = 1389$ students (girls $= 742$; boys $= 621$; preferred not to say $= 26$; average age $= 17.0 \pm 0.8$ SD years). Students attending the activities at the department of physics, biology, and chemistry were $N = 536$ (girls $= 192$; average

age $= 17.0 \pm 0.8$ SD), $N = 395$ (girls $= 327$; average age $= 17.0 \pm 0.7$ SD), $N = 432$ (girls $= 223$; average age $= 17.0 \pm 0.8$ SD), respectively. The association between gender and chosen discipline was statistically significant with a medium effect size ($\chi^2 = 204.251$; d.o.f. $= 2$; $p < 0.001$; Cramers' $V = 0.39$) and reflecting the students' distribution at undergraduate courses in physics, biology, and chemistry at our university.

C. Instruments

To evaluate students' gender stereotypes, self-efficacy, perceived academic control, and STEM identity, we used the following scales:

(a) To assess the presence of sexist attitudes and feelings, we adopted the ambivalent sexism inventory (ASI) [49] adapted in Italian in Ref. [144]. The ASI questionnaire features 22 items on a 6-point Likert scale (1 = strongly disagree; 2 = disagree; 3 = somewhat disagree; 4 = somewhat agree; 5 = agree; 6 = strongly agree). The scale consists of the subscale of hostile sexism (HS), which targets negative stereotypes of women, rejecting female roles and behaviors, and that of benevolent sexism (BS), which targets attitudes toward stereotypical traditional female roles. Example items of the HS scale are as follows: *Women are too easily offended*; and *when women lose to men in a fair competition, they typically complain about being discriminated against*. Example items of the BS scale are as follows: *No matter how accomplished he is, a man is not truly complete as a person unless he has the love of a woman; women, compared to men, tend to have a superior moral sensibility.*

(b) To measure identification in gender stereotypes based on a male, patriarchal, and traditional ideology, we used the male role norm cale (MRNS) [145,146]. We adopted the reduced 14-item scale with a 6-point Likert scale (same as the ASI scale). The MRNS is associated with three latent dimensions: social status of males; toughness; antifeminism. Example items are as follows: *Nobody likes a man who discloses worries; I like a man who's sure of himself; it is embarrassing for a man to cry at a movie*; respectively.

(c) To measure self-efficacy in STEM, we adopted the general self-efficacy (GSE) adapted to each discipline. We used the Italian reduced 10-item scale version [147] with a 5-point Likert scale (1 = strongly disagree; 2 = somewhat disagree; 3 = nor agree, neither disagree; 4 = somewhat agree; 5 = strongly agree). Example items were as follows: (when studying physics, biology, and chemistry) *I can always manage to solve difficult problems if I try hard enough; It is easy for me to stick to my aims and accomplish my goals.*

(d) Perceived academic control (PAC) was measured using the Italian eight-item scale version adapted from Ref. [130] with a 5-point Likert scale (same as self-efficacy). Example items are as follows: (when studying physics, biology, and chemistry) *The more effort I put into my courses, the better I do in them; My grades are basically determined by things beyond my control and there is little I can do to change that.*

(e) We used two items built from prior studies [25,80–82] to measure STEM identity. According to the adopted theoretical framework, the two items measure the extent to which students perceive themselves as STEM persons and the extent to which they want to become professionals in the specific STEM discipline associated with the activities they were attending (biology, chemistry, physics). The two-item scale used a 5-point Likert scale (same as self-efficacy). The items were as follows: *I easily image myself as a biology, chemistry, or physics person; I easily image myself as a biology, chemistry, or physics researcher.* The choice of using the two-item scale as a proxy to measure STEM identity can be justified from the measurement model viewpoint. In particular, prior studies that adopted the physics identity framework model consistently showed that four factors (performance or competence, interest, sense of belonging, and recognition) are antecedents of identity. In these studies, the four factors are latent variables while identity is a measured construct, in particular, through a single item (*I easily image myself as a STEM person)* [80–82], which has therefore a very high correlation (>0.80) with the composite score obtained taking into account the scores in the antecedent factors. Hence, the four antecedents do not measure the *same* construct of the identity item, but, rather, they are *predictors* of identity. That is, for example, increasing STEM interest corresponds to increasing STEM identity. Moreover, all the studies that used the same framework as in Refs. [80–82] *do not* validate a *second-order* model in which identity is itself a latent variable. Therefore, it is incorrect to use the antecedents' items *and* the single item *I easily image myself as a STEM person* to measure identity (see also Ref. [148] for further details about first-order and second-order measurement models). However, our choice to use two items instead of a single item as in Ref. [82] merits some further consideration. In particular, we added a second item to improve the reliability of the measurement by including in the biology, chemistry, or physics identity also the research dimension, which, in the Italian educational context, is associated very frequently with biologists, chemists, and physicists as professionals, while not coinciding exactly with *being* a biologist, a chemist, and a physicist in the professional life. Hence, given the alignment with prior research on the relationship between identity and career pursuits, both from a theoretical and a measurement perspective, we think that our two-item scale can be a better proxy for STEM identity than a single item. Finally, note that, during the revision, we have become acquainted with a four-item scale of STEM identity published very recently [89], which we are currently validating in the Italian context.

Finally, expected undergraduate course of choice at university, two items on a 4-point Likert scale ($1 =$ not all; $4 =$ definitively) targeting the willingness to purchase a STEM-related career—*I consider myself a person who wants to do a STEM profession (Mathematics, Physics, Science, Engineering)* and *I like science and technology and I have qualities that can be good for a STEM profession (Mathematics, Physics, Science, Engineering)* and gender were asked at the end of the survey.

Overall, the survey included 60 items. The average time for completion was 45 min.

D. Data analysis

The measurement model (ASI, MRNS, GSE, PAC, and STEM identity) was tested using confirmative factor analysis (CFA). The goodness of the data fit was assessed through the typical indices used in the literature [149,150]: $\chi^2/\text{d.o.f.} < 3$, RMSEA (root mean squared error of approximation) <0.08, TLI (Tucker-Lewis index), and CFI (comparative fit index) >0.95.

The model in Fig. 1 was tested through path analysis, using the factorial scores obtained from the CFAs (two-stage approach) [151]. The significance of indirect effects between variables (mediations) was measured through the bootstrap technique, in which the starting data, treated as a pseudopopulation, are compared with a random sample to determine whether the effect falls within a confidence interval. To assess the differences between female students and male students and between students' participating in the different activities (physics, biology, and chemistry), a multigroup structural analysis was carried out.

Convergent validation evidence [152] for the two-item STEM identity scale was established by evaluating the association with the expected undergraduate course of choice at university (e.g., biology, chemistry, physics) using a one-way analysis of variance (ANOVA) and by calculating Pearson correlation with the average score of the two items targeting the willingness to purchase a STEM-related career. The reason for using such a procedure is twofold. First, according to standards of psychological testing [152], convergent validity evidence must be established using two instruments that are expected to measure the same (or a very closely related) construct, and STEM identity is a strong predictor of pursuing a STEM career. Second, the same procedure was adopted in a prior study [82] to establish the convergent validity of the one-item identity scale.

TABLE I. Final Cronbach alphas of the scales used in the study.

Scale	Number items	α
HS	11	0.92
BS	11	0.89
MRN	10	0.86
GSE	10	0.85
PAC	6	0.76
STEM identity	2	0.90

All the statistical analyses were carried out through the software SPSS v. 27. Confirmatory factor analyses and path analyses were carried out through AMOS v. 27.

V. RESULTS

A. CFAs and reliability of the instruments

Our analysis confirmed a two-factor structure for the ASI, with hostile sexism (HS) and BS as the latent factors. Fit indices were satisfactory: $\chi^2/\text{d.o.f.} = 3.229$ ($p < 0.000$); $\text{TLI} = 0.967$; $\text{CFI} = 0.973$; $\text{RMSEA} = 0.040$. The correlation between HS and BS factors was 0.73. CFA of the MRNS did not support a three-factor structure. After removing four items, we found a satisfactory fit with a one-factor structure: $\chi^2/\text{d.o.f.} = 3.147$ ($p < 0.000$); $\text{TLI} = 0.98$; $\text{CFI} = 0.994$; $\text{RMSEA} = 0.039$. GSE and PAC scales were tested in the same CFA as a two-factor structure, with self-efficacy (SE) and academic control (AC) as latent factors. Results were satisfactory: $\chi^2/\text{d.o.f.} = 3.003$ ($p < 0.000$); $\text{TLI} = 0.964$; $\text{CFI} = 0.976$; $\text{RMSEA} = 0.038$. The correlation between the GSE and PAC factors was 0.66.

For the two-item identity scale, we first calculated a one-way analysis of variance (ANOVAs) using the average raw score of the two items as the dependent variable and the intention to enroll in a university course as the independent variable with five values: engineering or physics (23.5%); biology, chemistry, or Earth science (23.8%); math (3.7%); Non-STEM, e.g., health, humanities, economics (29.2%); undecided (19.8%).

Results show a significant association (Welch's $F = 68.790$; $\text{d.o.f.} = 4$, 312.947; $p < 0.001$). In particular, the non-STEM and the undecided groups scored significantly lower ($M = 2.44$;$\text{SD} = 1.09$; $N = 681$) than the engineering/physics, math, and biology/chemistry/Earth science group ($M = 3.38$; $\text{SD} = 1.08$; $N = 708$), $t = 16.044$; $\text{d.o.f.} = 1387$; $p < 0.001$. Pearson correlation between the average score of the two-item identity scale and the average score of the two items that measured the willingness to purchase a STEM-related career was 0.83 ($p < 0.01$).

Cronbach's alpha for each scale of our measurement model is reported in Table I.

B. Descriptive statistics

Tables II and III report the breakdown of the statistics of the scales used in the study for the gender variable and the

TABLE II. Descriptive statistics with t test for gender differences on the adopted scales.

Scale	Girls ($N = 742$): M (SD)	Boys ($N = 621$): M (SD)	t (d.o.f.)	*Cohen's d*
Hostile sexism	2.05 (0.93)	2.90 (1.10)	−15.251 (1217.648)[b]	−0.84[f]
Benevolent sexism	2.49 (1.07)	3.07 (1.03)	−10.057 (1361)[b]	−0.55[e]
Male role norm	2.34 (0.91)	3.13 (0.94)	−15.769 (1361)[b]	−0.86[f]
General self efficacy	3.60 (0.61)	3.66 (0.56)	−1.575 (1361)[ns]	−0.09[c]
Perceived academic control	4.01 (0.61)	4.08 (0.62)	−1.967 (1361)[a]	−0.10[c]
STEM identity	2.78 (1.15)	3.08 (1.20)	−4.613 (1361)[b]	−0.25[d]

[a] $p < 0.05$;
[b] $p < 0.001$;
[c] Negligible.
[d] Small.
[e] Medium.
[f] Large.
[ns] $p > 0.05$.

TABLE III. Descriptive statistics with ANOVA test for group differences on the adopted scales.

Scale	Students choosing physics activities ($N = 544$): M (SD)	Students choosing biology activities ($N = 403$): M (SD)	Students choosing chemistry activities ($N = 442$): M (SD)	$F\,(df)$
Hostile sexism	2.52 (1.09)	2.16 (1.00)	2.56 (1.15)	18.704[c] (2, 898.666)[b]
Benevolent sexism	2.89 (1.05)	2.52 (1.10)	2.77 (1.11)	13.606 (2, 1386)[b]
Male role norm	2.91 (0.99)	2.48 (0.93)	2.63 (1.02)	23.874[c] (2, 897.737)[b]
General self efficacy	3.72 (0.52)	3.66 (0.63)	3.46 (0.61)	26.464[c] (2, 859.547)[b]
Perceived academic Control	4.16 (0.53)	4.04 (0.64)	3.88 (0.68)	26.268[c] (2, 852.979)[b]
STEM identity	3.15 (1.13)	2.54 (1.19)	2.97 (1.15)	32.689 (2, 1386)[b]

[a] $p < 0.05$;
[b] $p < 0.001$;
[c] Welch's F.

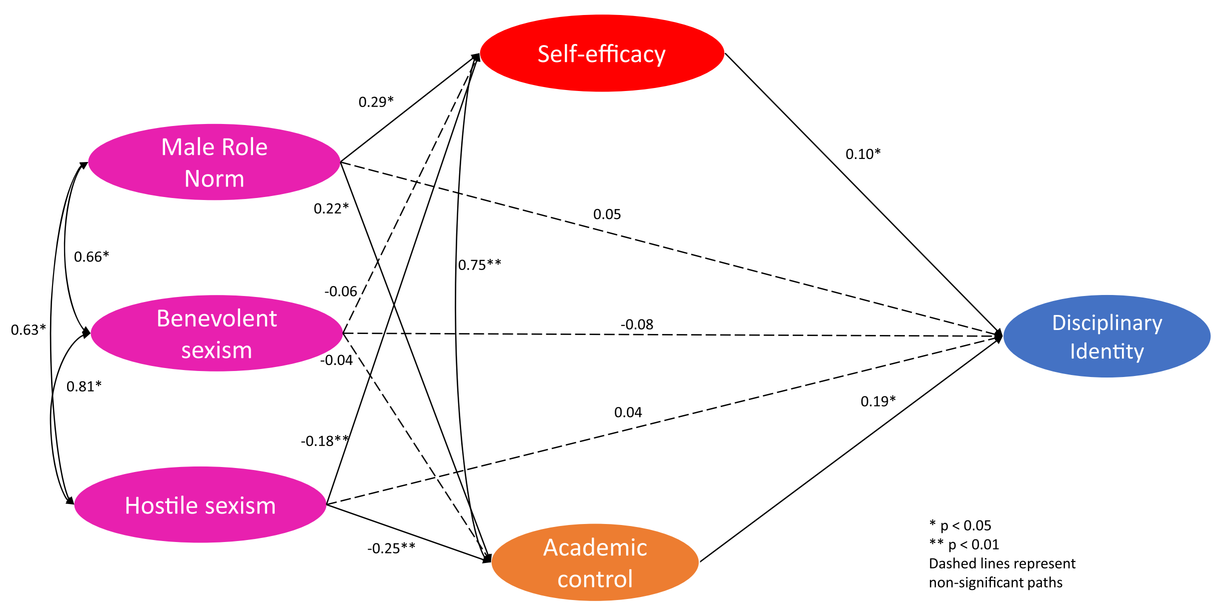

FIG. 2. Path analysis for the whole sample showing the relationships between gender stereotypes, self-efficacy, perceived academic control, and disciplinary identity.

TABLE IV. Unstandardized indirect effects of the gender stereotypes on disciplinary identity (whole sample).

Path	Estimate	Lower	Upper	p
Male role norm → Academic control → STEM identity	0.119	0.069	0.185	0.009
Hostile sexism → Academic control → STEM identity	−0.074	−0.123	−0.048	0.005
Male role norm → Self-efficacy → STEM identity	0.081	0.028	0.150	0.012
Hostile sexism → Self-efficacy → STEM identity	−0.028	−0.058	−0.010	0.006

three areas of the activities that the students attended. Differences between girls and boys are significant for all the stereotypes scales with girls scoring significantly lower, as expected from the literature. Differences in general self-efficacy are not statistically significant, while differences in perceived academic control are statistically different but with a negligible effect size. Gender differences in disciplinary (physics, biology, chemistry) identity are statistically significant with boys scoring significantly higher on this scale, as expected from the literature. We also note that girls reject more HS stereotypes than BS stereotypes ($t = 14.323$, $df = 741$, $p < 0.001$) and MRN stereotypes ($t = 8.648$, $df = 741$, $p < 0.001$) while also boys reject more HS stereotypes than BS stereotypes but to a lower extent ($t = 4.255$, $df = 620$, $p < 0.001$).

Differences among the three groups of students are statistically significant for all the stereotypes scales, with the biology group scoring lowest in the three scales, as expected given its gender composition. The three groups scored significantly different also in the GSE scale, the PAC scale, and the STEM identity scale.

We note that, on the latter scale, each group scored significantly different from the other (R-E-G-W interval, $p < 0.05$), with students who attended the physics activities scoring highest on the scale.

C. Path analyses

Full sample.—The path analysis for the whole sample is shown in Fig. 2. Concerning direct effects, we found, as hypothesized, that both self-efficacy and academic control predicts disciplinary identity. Moreover, endorsement of stereotypes related to typical male role norms (hostile sexism) positively (negatively) predicts self-efficacy and academic control. We found no direct effects of endorsement of the targeted gender stereotypes on disciplinary identity.

Table IV reports the four significant indirect effects. Our analysis shows that academic control and self-efficacy are both full mediators of the relationship between male role norms and hostile sexism stereotypes and STEM identity.

Gender differences.—In Fig. 3, we report the structural paths for girls and boys. We found that endorsement of stereotypes related to male role norms is positively associated with both self-efficacy and perceived academic control, and this effect is significant for both girls and boys. Similarly, the endorsement of hostile sexism stereotypes is negatively associated with both self-efficacy and

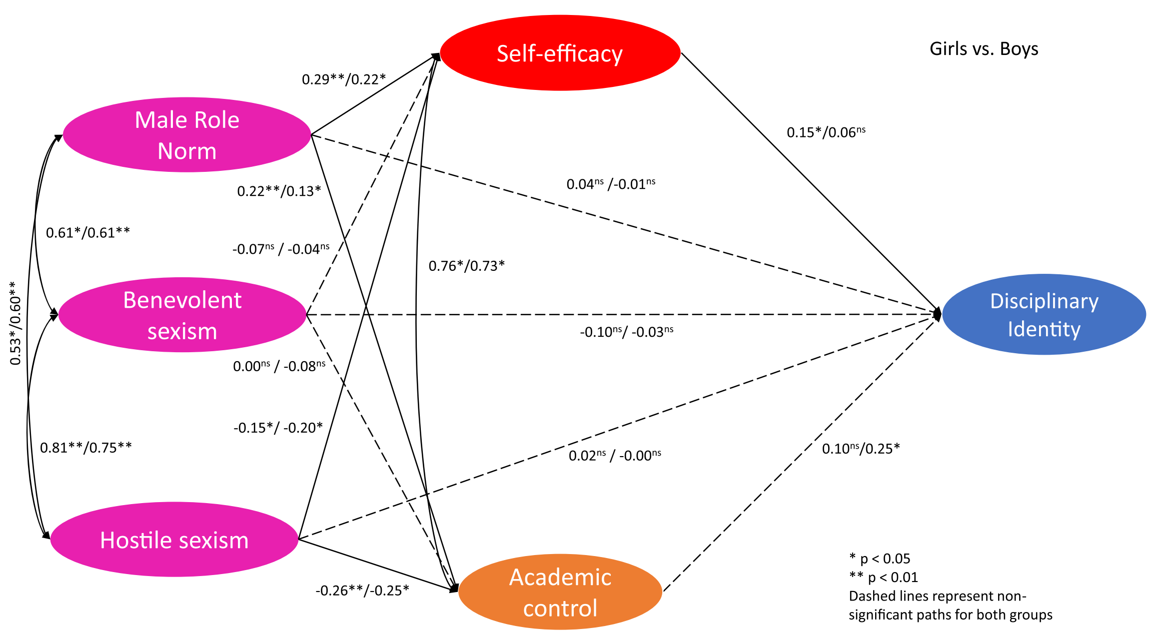

FIG. 3. Path analysis showing the relationships between gender stereotypes, self-efficacy, perceived academic control, and disciplinary identity for girls and boys involved in the study. Results are reported in the format: girls/boys.

TABLE V. Unstandardized indirect effects of the gender stereotypes on disciplinary identity for girls and boys.

Path	Group	Estimate	Lower	Upper	p
Male norm → Self-efficacy → STEM identity	Girls	0.135	0.056	0.245	0.004
	Boys	0.037	−0.023	0.131	0.305
Male norm → Academic control → STEM identity	Girls	0.064	0.008	0.141	0.056
	Boys	0.101	0.033	0.203	0.017
Hostile sexism → Self-efficacy → STEM identity	Girls	−0.042	−0.106	−0.013	0.006
	Boys	−0.018	−0.077	0.014	0.305
Hostile sexism → Academic control → STEM identity	Girls	−0.044	−0.108	−0.005	0.063
	Boys	−0.099	−0.168	−0.043	0.013

perceived academic control and also this effect is significant for both girls and boys. Differently, self-efficacy has a positive significant effect on disciplinary identity for girls but not for boys. The reverse happens for the positive relationships between perceived academic control and disciplinary identity, which is significant only for boys. Direct effects of the endorsement of gender stereotypes on disciplinary identity are nonsignificant for both boys and girls. Differences between the path coefficients for boys and girls are not statistically significant. Concerning indirect effects, we report in Table V the result of the multigroup analysis. For girls, the effects of the endorsement of male role norms and hostile sexism stereotypes on disciplinary identity are fully mediated by self-efficacy. For boys, the mediator between male role norms and hostile sexism stereotypes, and disciplinary identity is the perceived academic control. Differences in strength between the regression coefficients for both direct and indirect effects for boys and girls are not statistically significant, as confirmed by a chi-square statistics model comparison ($\Delta\chi^2 = 13.623$, $df = 11$, $p = 0.255$).

Discipline differences.—In Fig. 4, we report the structural paths for the three groups of students (physics, biology, and chemistry activities), respectively. We found that, for all groups, there is no direct effect of stereotypes on disciplinary identity. The endorsement of male role norms and hostile sexism stereotypes is significantly associated with self-efficacy and perceived academic control for students who followed the physics and biology activities, while such association is not significant for students of the chemistry activities. In turn, self-efficacy predicts disciplinary identity only for students who attended the physics activities, whereas perceived academic control predicts disciplinary identity only for students who followed biology and chemistry activities. Differences in structural weights are significant across groups ($\Delta\chi^2 = 42.176$,

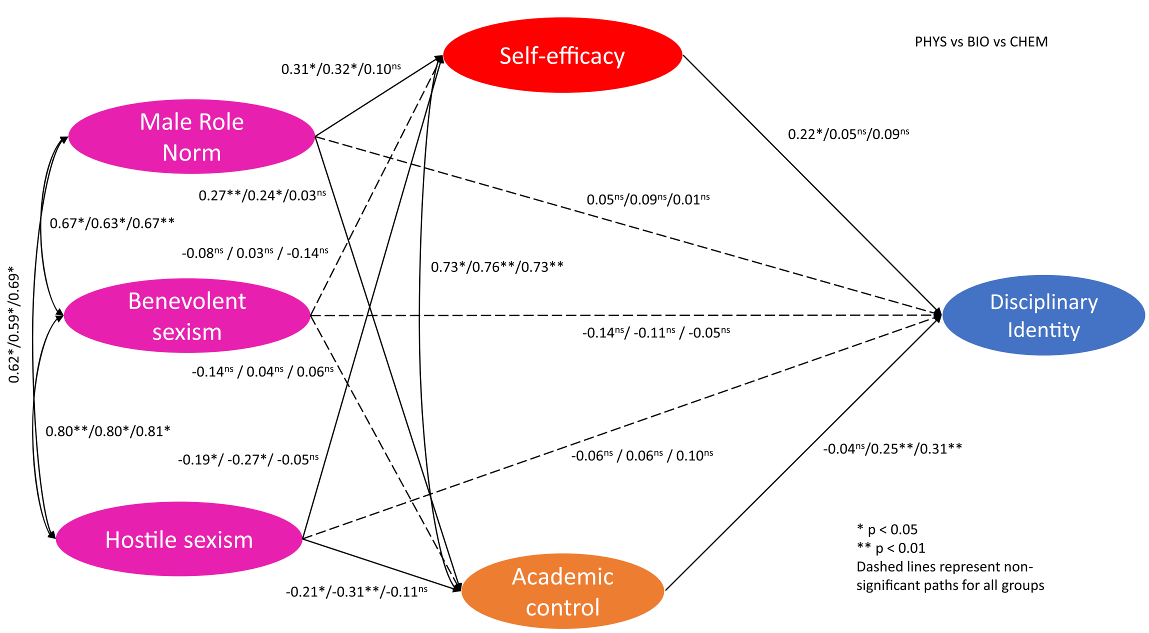

FIG. 4. Path analysis showing the relationships between gender stereotypes, self-efficacy, perceived academic control, and disciplinary identity for students attending extracurricular activities in physics, biology, and chemistry. Results are reported in the format: physics/biology/chemistry.

TABLE VI. Unstandardized indirect effects of the gender stereotypes on disciplinary identity for the three groups of students involved in the study.

Path	Group	Estimate	Lower	Upper	p
Male norm → Self-efficacy → STEM identity	Physics	0.181	0.072	0.274	0.020
	Physics vs chemistry	0.158	0.042	0.263	0.038
Male norm → Academic control → STEM identity	Biology	0.182	0.076	0.314	0.005
	Physics vs biology	−0.212	−0.371	−0.094	0.006
Hostile sexism → Self-efficacy → STEM identity	Physics	−0.061	−0.127	−0.019	0.012
	Physics vs chemistry	−0.068	−0.14	−0.021	0.006
Hostile sexism → Academic control → STEM identity	Biology	−0.134	−0.271	−0.077	0.001
	Physics vs biology	0.147	0.075	0.288	0.003

$df = 22$, $p < 0.01$). In particular, we found that the (positive) paths between male role norm and self-efficacy are significantly higher for students who attended physics and biology activities with respect to students who attended chemistry activities ($p < 0.05$).

Similarly, the (positive) path between male role norm and perceived academic control is significantly higher for students who attended the physics activities with respect to students who attended the chemistry activities ($p < 0.05$). The (negative) path between hostile sexism and self-efficacy is sig, nificantly higher for students who attended the biology activities with respect to students who attended the chemistry activities ($p < 0.01$). Finally, the (positive) path between academic control and disciplinary identity is significantly stronger for students who attended the biology and chemistry activities with respect to students who attended the physics activities ($p < 0.01$).

Finally, we report in Table VI the significant indirect effects and the corresponding groups for which they are significantly different. First, we note that full mediation effects are significant for students who followed the physics and biology activities. In particular, for physics students, self-efficacy is a significant mediator for both the relationships of male role norms and hostile sexism with disciplinary identity. For biology students, the role of mediator between the stereotypes and the disciplinary identity is played by perceived academic control.

We also note that the indirect effects, with academic control as a mediator, are significantly different between physics and biology groups, whereas the indirect effects, with self-efficacy as a mediator, are significantly different between physics and chemistry groups.

VI. DISCUSSION

The main aim of this paper was to contribute to research about the reasons for lower percentages of girls undertaking specific STEM careers by testing whether the endorsement of explicit gender stereotypes based on ambivalent sexism (benevolent and hostile) and male role norms affects the STEM disciplinary identity of high school students. The second aim was to test whether self-efficacy beliefs and perceived academic control mediate such a relationship. We also looked for gendered patterns in our model and investigated whether different orientations toward three STEM disciplinary areas, physics, biology, and chemistry, affected such relationships.

In the following paragraphs, we discuss our results according to the research questions that guided the study.

A. RQ1: The relationship between gender stereotypes and disciplinary identity

It had been shown in previous studies that implicitly adopted stereotyped views of science and engineering affect the disciplinary identity of boys and girls [153]. Our results show that the endorsement of explicit gender stereotypes based on ambivalent sexism and role male norms does not directly affect high school students' STEM disciplinary identity when including self-efficacy and perceived academic control in the model. The relationship is invariant with respect to gender and to disciplinary orientation toward extracurricular activities. In other words, increasing agreement with sexism stereotypes, as measured by the ASI scale, and masculine role norms, as measured by the MRN scale, does not reflect on increased (or decreased) STEM disciplinary identity. Additionally, our result does not seem to depend on the specific STEM disciplinary area of interest, thus suggesting that also domain-specific disciplinary identities are not directly shaped by adherence to gender stereotypes. Taking physics and biology as examples, an increasing adherence to masculine ideologies does not increase a student's physics identity, as well as a decreasing endorsement of hostile stereotypes toward women does not increase biology identity.

In the following, we discuss such results under the two theoretical perspectives adopted in this study: ambivalent sexism theory and masculine ideology paradigm. Since this is the first study, to our knowledge, that investigates how the endorsement of ambivalent sexism stereotypes affects STEM identity, we compare our results to previous studies related to perceived ambivalent sexism.

A review study in physics education suggested that perceived or experienced sexism (e.g., microaggressions) may justify girls' underrepresentation and dropout in physics and astronomy [154]. A quantitative study investigated the effects of hostile sexism experiences on intentions to major in STEM, self-efficacy, and STEM grades [155]. While the authors include also STEM identity in their models, they did not investigate whether disciplinary identity was affected by perceived sexism. Overall, they found that both benevolent and hostile sexism experiences affected the intentions to major in STEM and STEM self-efficacy but found no significant effect on performance, independently on the level of STEM identity, and this result seems in agreement with our findings. We will discuss later the effects on self-efficacy.

Similarly, we found that endorsing masculinity ideologies does not affect directly disciplinary identity. This null direct relationship holds independently on gender and specific STEM disciplinary area of interest. Since this is the first study that has analyzed the association between the endorsement of a masculine ideology with disciplinary STEM identity, we compare our results with literature about the relationships between masculine role norms and the choice of undergraduate courses. In the study in Ref. [156], the authors found that the choice of a gendered undergraduate course such as engineering or physics was not directly affected by adherence to masculine stereotypes, but that self-efficacy fully mediated this relationship (again, we will discuss this result later). Likewise, other authors [139], with a sample composed exclusively of men, found only one significant association between endorsement of male role norms and choice of major. In particular, they found that some specific traits of masculinity were negatively correlated with the choice of arts and humanities major compared to STEM or medicine courses.

Although the above result may suggest a possible direct effect between the endorsement of male role norms stereotypes and career choice, we note that, from the methodological viewpoint, the choice of including only males may have influenced the results. Moreover, another limitation of the study in Ref. [139] was to put together STEM and medicine courses. Indeed, previous results suggest that the two fields are perceived quite differently by girls and boys [71].

Finally, our results are in line also with those of a study about the influence of feminine and masculine personality traits and the choice of a STEM major [140]. In particular, the authors found no significant direct relationship between masculine personality traits and STEM major choice for both male and female students. The conclusion that disciplinary STEM identity is not directly affected by the endorsement of gender stereotypes may have different explanations. One possibility may be related to students' perception of the scientific and engineering work and research environment as characterized by positive traits such as the work ethics, the creativeness and problem-solving attitude, the respect for other's ideas, the value of teamwork, and the importance of international relationships. Our results suggest that high school students do not spontaneously associate STEM disciplines only with the stereotyped negative views such as the competitive climate and elitism. Rather, they moderate their perceptions with positive aspects of these disciplines, which are presumably conveyed by science teachers and school textbooks. As a consequence, as also suggested by prior studies [140], female and male students who endorse stronger masculine ideologies or endorse ambivalent sexism stereotypes are more likely to develop identities in disciplines where such stereotypes play a much more relevant role, such as politics [144].

B. RQ2: Role of mediators in the relationships between gender stereotypes and disciplinary identity

If the endorsement of explicit gender stereotypes related to ambivalent sexism and male role norms does not directly affect STEM identity, then, how can we explain gender inequality in STEM careers? Furthermore, how can we explain the different participation of girls and boys in different STEM fields? Our results suggest that gender stereotypes affect disciplinary identity although in a more nuanced way than prior work suggested, namely, through a possible mediation effect of two constructs, one of which, self-efficacy, is a known predictor of STEM identity, while the other, perceived academic control, is a predictor of persistence in academic choice. In other words, while prior research addressed only the latter relationships, our study may contribute to reveal the remnant of the picture, including the role of gender stereotypes as antecedents of such a relationship. When including in the model self-efficacy and academic control, differences related to gender and science domains clearly begin to appear. We will discuss our results separately for each of the constructs addressed in this study.

Self-efficacy.—We found that, for the whole sample, self-efficacy fully mediated the relationships between male role norms and hostile sexism with disciplinary identity in physics, biology, and chemistry. In particular, the endorsement of male role norms stereotypes positively affected self-efficacy, while the endorsement of hostile sexism negatively impacted self-efficacy. In turn, self-efficacy significantly affected disciplinary identity. The direct paths between gender stereotypes and self-efficacy are significant for both genders, whereas the relationship between self-efficacy and disciplinary identity is significant only for girls. Consequently, the mediation effect appears only in the female students group. When considering the three disciplines targeted in the study, the regression paths between male role norms and hostile sexism stereotypes and self-efficacy are significant for students who chose the physics and biology activities, whereas the path between self-efficacy and disciplinary identity is significant only for the students who attended the physics activities. In other words, self-efficacy fully mediates the relationships between gender stereotypes and identity, but only for physics.

Concerning the direct effects of stereotypes on self-efficacy, our results are in agreement with prior literature that reports that endorsement of masculine ideologies predicts academic self-efficacy [156] and that perceived ambivalent sexism may affect women's self-efficacy due to cognitive mechanisms that lower their sense of competence [136]. Our study extends the latter findings by showing that the endorsement of hostile sexism stereotypes significantly decreases the perceived self-efficacy. For boys, this relationship may be explained considering that hostile attitudes are most likely caused by feelings of fear of losing a predominant position. For girls, the adherence to a hostile stereotype is likely to be due to the perception of being required to reject some elements of women's gender identity to fit into the STEM culture and this may decrease the perceived self-efficacy. We note that this relationship holds for students who chose to participate in activities in strongly gendered STEM fields, such as physics and biology, but not for students who chose chemistry activities. This can be possibly due to a nonstereotyped view of chemistry, differently from that of physics and biology. In contrast with prior studies [157], which, however, were focused on the perceived benevolent sexisms, our study suggests that endorsement of benevolent sexism stereotypes has no effect on self-efficacy.

Concerning the mediation effect on the whole sample, our findings confirm those in Ref. [156], according to which the endorsement of male role norms predicts academic self-efficacy which in turn predicts STEM career choice. Our findings are also consistent with those of the study described in Ref. [71], which compared STEM with health care, elementary education, and the domestic spheres (HEED) career intention. Findings show that self-efficacy partially mediated gender differences in interest for STEM majors but not for HEED majors. The latter result is consistent with our finding that self-efficacy fully mediated the relationships between gender stereotypes and disciplinary identity only for women across the disciplines, and only for physics, independently on gender. The latter result confirms the evidence of recent studies in physics education [28,95,96,158] according to which the relationship between gender and physics identity is mediated by self-efficacy. Overall, these findings explain some of the nuanced mechanisms underlying the underrepresentation of girls in STEM. The findings for boys confirm that stronger adherence to gender stereotypes based on masculine ideology and ambivalent (hostile) sexism does not lead to a higher STEM identity through self-efficacy. On the other hand, this route is likely to be the basis of higher STEM identity of girls. We found that girls who more strongly endorsed male role norms were more likely to feel more confident in their own capabilities when dealing with the STEM disciplines, which in turn increased their self-image as STEM persons. Hence, as already pointed out above, probably, it is not the association of STEM disciplines with masculine practices [82] or with a general "chilly climate" [159] that discourages girls from pursuing a STEM career, but, rather, the perception that a masculine ideology is necessary to feel more competent, and hence more successful, in STEM disciplines. Interestingly, for girls, the rejection of hostile sexism stereotypes has a smaller effect (0.15 vs 0.29) on increasing the perceived self-efficacy than the adherence to the male role norms stereotypes. This result is in agreement with previous studies on perceived sexism [155], according to which women perceived less frequently hostile sexism in STEM disciplines classes. As a consequence, girls may not be fully aware of the damages of hostile sexism stereotypes. We also note that different from the results of the same study, the rejection of benevolent sexism did not significantly affect self-efficacy independently on gender and specific science discipline.

Perceived academic control.—We found that for the whole sample, academic control fully mediated the relationships between male role norms and hostile sexism with disciplinary identity in the targeted science domains (physics, biology, and chemistry). In particular, endorsement of male role norms stereotypes positively and significantly affected perceived control, while the effect of endorsement of hostile sexism was negative and significant. In turn, perceived control significantly affected disciplinary identity, with a larger effect than self-efficacy. The paths between gender stereotypes and academic control are significant for both genders, whereas the relationship between academic control and disciplinary identity is significant only for boys (although, it is significant also for girls at $\alpha = 0.10$ level). Consequently, a significant mediation effect appears only in the male students group. When considering the three disciplines targeted in the study, the regression paths between male role norms and hostile sexism and perceived academic control are significant for students who chose the physics and biology activities, whereas the path between academic control and disciplinary identity is significant only for the students who attended the biology and chemistry activities. In other words, academic control fully mediates the relationships between gender stereotypes and identity for chemistry and biology, but not for physics.

Concerning the direct effects of stereotypes on perceived academic control, our findings suggest that higher levels of perceived academic control in the disciplines targeted by our study are predicted by higher levels of endorsement of male role norms, for both girls and boys. A possible reason is that a stronger adherence to male role norms may be linked to increased perceptions of responsibility and feelings of shame in case of failures and hence an increased perception of potential control over events [160]. A concurrent explanation is that students with higher levels of perceived control feel more pride in their achievement, and this behavior may be linked to masculine stereotypes [161]. A new and interesting finding of our study is that also the rejection of hostile sexism has a significant effect on academic control. This finding may be explained by considering that a lower perception of academic control is related to higher tendency to attribute failures to uncontrollable factors, such as natural ability or unfriendly class environment, which are often associated with stereotyped views of STEM. Therefore, the rejection of hostile sexism may be linked to students' tendency to focus on more personally controllable factors, such as effort in studying and learning strategies. This result also contributes to understand inconsistencies in studies about the stereotype threat effect [162–164]. These studies suggest that differences in perceived ability and actual performance between boys and girls in physics and math may be explained by the activation of negative stereotypes inherent to contextual factors such as the presence of male peers [165] or taking a diagnostic test [166,167], factors that are beyond the student's control. These interpretations of the gender gap in physics and math performances are controversial and the extent to which the stereotype threat actually affects girls' performance is still highly debated [168]. Our findings suggest that stereotype threat conditions are expected to be activated when students endorse hostile sexism stereotypes in a specific learning environment and, since such adherence may vary across populations, results can vary accordingly, leading to inconsistent evidence of the stereotype threat. Our study suggests to include also measures of hostile sexism and perceived academic control to better control experimental conditions in these studies.

Finally, we comment on the existence of an indirect effect of gender stereotypes based on masculine ideology and hostile sexism on disciplinary identity mediated by the perceived academic control for the whole sample, and in particular boys. This finding suggests that it is not the bare representation of STEM disciplines as masculine to motivate male students in choosing STEM-related career, but, more probably, the perception that the adherence to a masculine ideology can increase the feeling to be able to control the performance in these disciplines. Consequently, to reduce the perception of femininity as incongruent with the STEM identification, it would be necessary to deconstruct the masculine view of controllable factors such as individual ability, responsibility, and feelings of shame, which, through academic control, affect the identification in STEM disciplines.

VII. LIMITATIONS

Although our study is the first to our knowledge to investigate the link between the endorsement of gender stereotypes, self-efficacy, perceived academic control, and STEM identity, the following limitations should be acknowledged. First, our findings are limited by the cross-sectional nature of our data. Longitudinal data could have improved the validity of our results, especially the full mediation mechanism envisaged in our model. Second, we measured the explicit endorsement of gender stereotypes using only students' self-reports. As such, responses may be affected by social desirability bias, especially on the ASI scale. Third, the students in our sample participated voluntarily in the activities of the Piano Nazionale Lauree Scientifiche and were reasonably more interested in STEM disciplines than the average student population, independently of their choice of pursuing a STEM career. Therefore, these students do not represent the general upper secondary school student population since those who already lost their interest in pursuing STEM professions were not included in the study. This selection bias clearly limits the generalizability of our results. In particular, the population of high school students attending classical lyceums and technical or vocational schools, which are female and male segregated respectively, is underrepresented in our sample. We are currently exploring whether the type of high school attended is associated with the endorsement of gender stereotypes and whether the choice of a given type of high school is predicted by the endorsement of gender stereotypes. Similarly, all students in our sample had a medium-high socioeconomic background and this specificity further limits the generalizability of our results.

Finally, this study did not control for students' prior experience with the targeted STEM areas (e.g., the number of biology, chemistry, and physics extracurricular activities attended before participation in the study), so it is difficult to establish whether the differences in self-efficacy, perceived academic control, and disciplinary identity can be explained by these prior experiences. In a future study, we are planning to explore the relationships described in this paper controlling for prior experience with the specific STEM discipline.

VIII. CONCLUSIONS

While much of the prior research about the gender gap in STEM has been focused on the influence of stereotyped views of science and engineering, this study is the first to investigate whether the endorsement of masculine and sexism stereotypes affects students' disciplinary identity in science. Moreover, this is one of the few studies that distinguish between physics, biology, and chemistry, according to the interest manifested by the student to participate in extracurricular activities in these three domains. Our results suggest that the explicit endorsement of gender stereotypes, an issue that has been overtly overlooked, has a substantial, yet indirect, effect on the development of a disciplinary identity in the STEM domain. In particular, the most important conclusions are that, for both girls and boys, the adherence to male role norms and the rejection of hostile sexism have, respectively, a positive and a negative indirect effect on disciplinary identity. In particular, the endorsement of these stereotypes directly affects self-efficacy and perceived academic control, which in turn affects disciplinary identity. These findings suggest going beyond the simple refusal of the "women do not like STEM because is not feminine" stereotype and to deeply rethink strategies aimed at increasing women's presence in STEM careers. The role of self-efficacy and academic control as mediators suggests to focus more on girls' own perception of competency and responsibility, rather than solely focusing on the sense of belonging and recognition, which are difficult to achieve in the transition between high school and undergraduate university studies. Our study also suggests that the identity in the three addressed STEM domains is differently affected by stereotypes, with physics and biology being more largely affected than chemistry. Findings from future studies on how identity in different STEM disciplines is affected by gender stereotypes may further contribute to our knowledge of how to reduce the gender gap in STEM careers.

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